SAFKEG-HS 3977A

SARP Update Matrix for Thorium Target

Title	SAFKEG-LS 3977A SARP Update Matrix for Thorium Target	Number	CTR 2018/01
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Contents

1 Notes on methodology and content

This Update Matrix document (CTR 2018/01) details the changes in the SAFKEG-HS 3977A SARP in updating from Rev 13 to Rev 14.

This SARP update is to allow Thorium targets to be carried in the package as new Contents Type 6 (CT-6).

This Update Matrix document will be updated during the NRC review process to include responses to questions from the NRC, thereby fully documenting all changes made during the entire SARP update.

Minor editorial changes in the SARP to clarify and correct errors are also detailed in this Update Matrix document.

This Update Matrix document (CTR 2018/01) provides the following in updating from Rev 13 for the addition of Thorium targets.

- Details of SARP supporting document changes proposed with reason for the change - Table 1
- Question and Response Matrix - Table 2 (this includes all the updates made to the SARP to answer all the questions posed by the NRC)
- List of new or edited supporting documents provided in the SARP – Table 3, Appendix A
- Explanation of the approach taken for new contents type CT-6 (radioactive thorium target) - Appendix B.

2 Reason for the changes in the SARP in updating from Rev 13

Ac-225 is being developed for medical purposes and LANL have developed a methodology of producing Ac-225 by irradiating of a thorium target in a proton beam. The SAFKEG-HS 3977A has been identified by LANL as appropriate package for shipping irradiated thorium targets and Croft have been contracted to have irradiated thorium targets added to the SARP.

3 SARP Changes

This table contains notes on all the SARP Page Changes and supporting Document Changes.

Table 1 Summary of SARP Changes and Supporting Document Changes for Rev 14

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	**Location**	**Change**	**Reason for Change**
Sections 0 to 8	Throughout the SARP	The Rev status has been updated to Rev 14 for all SARP pages and not just pages with changes.	This change has been made to simplify management of the SARP for which master documents are electronic Word documents. This change reduces the potential for editorial errors and also facilitates the production of pdf copies produced for reviewers (simplified as each Section will be complete and not just be separate pages All changes to the SARP from the previous revision are shown in the "Compare" documents provided for each Section.
	Throughout the SARP These are shown in the "Compare" documents provided for each Section.	Editorial changes have been made to correct errors, standardise terminology, etc.	To correct errors, standardise terminology, etc.
All pages	Header throughout the SARP Footer throughout the SARP	Page Rev status amended to Rev 14 for all pages.	Changes required solely to change from page control to document control to facilitate future update.

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	**Location**	**Change**	**Reason for Change**
		Filename updated and date removed	Date not needed as it is the same for all pages as shown in Section 0.
Section 0 - Contents			
Page 0-2	Table	Updated for Rev 14	Editorial
	Section 0.2	Page status changed throughout	Update to of Rev
	Documents in Section 1.3.3	Headings have been added for the drawings for each version of the CV. The drawings for the Sealed Split Lid Version of the CV have been added.	This change is required to accommodate a thorium target.
	Documents in Section 3.5.2, Appendix	The document references, status and titles have been edited (for those docs having an External Report Number (ETR #) added).	The ETR #s and eFilenames have been added to facilitate finding electronic copies of these documents (they did not have Ref #s).
	Documents in Section 4.5.2, Appendix	Details for CS2018/01 added	
Section 1 - General Information			
Pages - various	Throughout Section	Editorial changes made as necessary for addition of the sealed split CV lid.	Editorial and clarification
Page 1-3	Section 1.2.1.3	Edited to add the CV seal plug having an O-ring seal.	

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	**Location**	**Change**	**Reason for Change**
Page 1-3	Section 1.2.1.3, 5th para	Details of the sealed split CV lid added	For new Contents Type CT-6
Page 1-4	Section 1.2.1.4	New Figures referenced	
Page 1-4	Section 1.2.1.5	New Figures referenced	
Page 1-8		Figure 1-1c added	Depicting split CV lid
Page 1-8		Details of the package with sealed split CV lid added	For new Contents Type CT-6
Page 1-12		Figure 1-2c added	Shows new sealed split CV lid
Page 1-16		Figure 1-3c added	Shows new sealed split CV lid
Page 1-19		Figure 1-4c added	Shows new sealed split CV lid
Page 1-21	Table 1.1	Contents mass limit for sealed split CV lid added	For new Contents Type CT-6
Page 1-24	Table 1.2	CTs renumbered CT-3 Gas reinstated [as Rev 11 of the SARP] CT-6 added	Editorial adjustment Deleted from the SARP at Rev 13 in error. For new Contents Type CT-6 – Thorium target
Page 1-27	Table 1.3.3	CT-3 Gas reinstated [as Rev 11 of the SARP]	Deleted from the SARP at Rev 13 in error.
Page 1-30	Table 1.3.6	CT-6 added	For new Contents Type CT-6 – Thorium target
Page 1-35	Table 1.4.3	CT-3 Gas reinstated [as Rev 11 of the SARP]	Deleted from the SARP at Rev 13 in error.

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	**Location**	**Change**	**Reason for Change**
Page 1-38	Table 1.4.6	CT-6 added	For new Contents Type CT-6 – Thorium target See also Appendix B
Page 1-46	Section 1.3.3.3 added	Drawings for the package having the new sealed split CV lid added	For new Contents Type CT-6 – Thorium target
Section 2 - Structural Evaluation			
Pages – 2-54, 2-55, 2-58,		Table numbering corrected.	Editorial
Section 3 - Thermal Evaluation			
Page 3-4a	Section 3.1.3, 4th para	Comment on temperatures for CT-6 added.	For new Contents Type CT-6 – Thorium target
Page 3-23	Section 3.5.2	Document references “ETR” added for MURR reports and Mallinckrodt report.	The ETR #s have been added to facilitate finding electronic copies of these documents (they did not have Ref #s).
Section 4 - Containment Evaluation			
Page 4-1 and elsewhere	Section 4.1, 1st para and elsewhere	Edited to accommodate new sealed split CV lid	For the new package assembly for CT-6.
Page 4-3	Figure 4-3	Figure 4-3 added.	For the new sealed split CV lid for CT-6.
Page 4-4	Table 4-1, note (2) and last para.	Note re dose rate for CT-4 added.	For the new package assembly for CT-6.
Page 4-5	Section 4.2.2, 2nd and 3rd paras.	Edited for reinstatement of CT-3 (gas) and CT-6 (thorium).	Editorial for reinstatement of CT-3 and new CT-6.

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	**Location**	**Change**	**Reason for Change**
Page 4-6	Section 4.2.4, 4th to 7th paras.	Edited for reinstatement of CT-3 (gas) and CT-6 (thorium).	Editorial for reinstatement of CT-3 and new CT-6.
Page 4-7	Section 4.3.2, 2nd to 4th paras.	Edited for reinstatement of CT-3 (gas) and CT-6 (thorium).	Editorial for reinstatement of CT-3 and new CT-6.
Page 4-8, 4-9	Section 4.3.4.2, 3rd and 4th paras.	Edited for reinstatement of CT-3 (gas).	Editorial for reinstatement of CT-3.
Page 4-9	Section 4.4.1, 3rd para.	Requirements for testing the plug/body seal of the split lid sealed plug added.	For the new sealed split CV lid for CT-6.
Page 4-9	Section 4.4.2, 3rd para.	Requirements for testing the plug/body seal of the split lid sealed plug added.	For the new sealed split CV lid for CT-6.
Page 4-9	Section 4.4.3, 3rd para.	Requirements for testing the plug/body seal of the split lid sealed plug added.	For the new sealed split CV lid for CT-6.
Page 4-10	Section 4.4.4, 3rd to 5th paras.	Edited for renumbering the CTs and comments on not require a leak test for new CT-6.	For the new sealed split CV lid for CT-6.
Page 4-11	Section 4.5.2	Reference for new calculation sheet CS 2018/01 added.	For the gas contents of new CT-6.
CS 2018/01	Append to Section 4	New calculation sheet CS 2018/01 added.	For the gas contents of new CT-6.
Section 5 - Shielding Evaluation			
Page 5-1 and elsewhere	Section 5.1.1, 1st and 3rd paras.	Editorial re references, figure and table numbering.	Add references and figures for the new sealed split CV lid for CT-6.

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	**Location**	**Change**	**Reason for Change**
Page 5-3	Figure 5-2	Figure 5-2 edited to not show the Insert.	The figure shows the shielding but not the insert which does not provide significant shielding.
Page 5-43	Figure 5-3	Figure 5-5 added	Shows new sealed split CV lid
Page 5-10	Section 5.3.1, three paras following Table 5-3.	Information re MNCP calculations for CT-6 added.	For new CT-6
Page 5-10	Section 5.3.2	Data for neutron sources removed.	None of the radionuclides specified in the contests emit neutrons.
Page 5-11	Section 5.4.1	Editorial changes	Clarification
Page 5-11	Section 5.4.1, 5th para	Information re MNCP calculations for CT-6 added.	For new CT-6
Page 5-12	Table 5-4 Last row of table	Editorial [spelling] Information re MNCP calculations added.	Correction For new CT-6
Page 5-19	Figure 5-14	Figure 5-14 added to show Thorium target locations for MCNP Model	For new CT-6
Page 5-22	Section 5.4.2, after Table 5-6	Ref to materials properties for CT-6 added.	For new CT-6
Page 5-23	Section 5.5.1	Ref to calculation method for CT-6 added.	For new CT-6

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	**Location**	**Change**	**Reason for Change**
Page 5-23	Section 5.5.2	Ref to calculations for CT-6 added.	For new CT-6
Page 5-23	Section 5.5.3	Ref to dose rate conversion for CT-6 added.	For new CT-6
Page 5-28	Section 5.5.4.3	Details of 5.5.4.3 MCNP calculations for thorium target added.	For new CT-6
Page 5-32	Section 5.5.6	Ref for new calculation report for CT-6 /01 added.	For new CT-6
Atkins 5163778-HS-REP-001-001	Append to Section 5	New calculation report for CT-6 added.	For new CT-6
Section 6 - Criticality Evaluation			
Page 6-1, 6-2	Section 6	All details removed.	Consistency and clarification. The contents of this package are non-fissile and therefore no evaluation for the safety of fissile contents is required.
Section 7 - Operating Procedure			
Page 7-1	Section 7, 5th para	Editorial	Clarification
Page 7-2	Section 7.1.1 – title & para 8)	Editorial	Clarification
Page 7-3	Section 7.1.1 – para 11)	Drawing info added	For new sealed split lid CV
Page 7-4	Section 7.1.2 – para 7)	Editorial	Clarification
Page 7-5	Section 7.1.3 – Note	Editorial	Clarification

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	**Location**	**Change**	**Reason for Change**
Page 7-6	Section 7.1.4 – all paras	Loading requirements added for sealed split lid CV	For new CT-6
Page 7-7	Section 7.1.5 – title & para 4)	Editorial	Clarification
Page 7-7	Section 7.1.5, 1)	Editorial	To be consistent with ANSI N14.5 Section 7.6.4 acceptance criterion
Page 7-8	Section 7.2 1st para	Section references added	Clarification & for new CT-6
Page 7-9	Section 7.2.2 – paras 1) & 6)	Editorial “for contamination” added	Clarification
Page 7-10	Section 7.2.3 – paras 1) & 6)	Editorial “for contamination” added	Clarification
Page 7-11	Section 7.2.4 – all paras	Unloading requirements added for sealed split lid CV	For new CT-6
Page 7-14	Section 7.3,2 para 12)	Requirement added to ovoid damage	Consistency
Page 7-14	Section 7.1.4 – all paras	Loading requirements added for sealed split lid CV	For new CT-6
Page 7-14 & 71-15	Section 7.3.3 – all paras	Requirements added for shipment of empty package having a sealed split lid CV	For new CT-6
Section 8 - Acceptance Tests & Maintenance Program			
Page 8-1	Section 8, 4th para	Para added	Consistency with Section 7
Page 8-2	Section 8.1.2	Drawing info added	For new sealed split lid CV and clarification
Page 8-2	Section 8.1.3 - 2nd para	“as specified” added	Clarity

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	**Location**	**Change**	**Reason for Change**
Page 8-2	Section 8.1.4 - 1st para	Editorial	For new CT-6
Page 8-3	Section 8.1.4 penultimate para	Leak testing requirements added for new sealed split lid CV	For new CT-6
Page 8-3	Section 8.1.5.2 – 3rd para	Editorial	For new CT-6
Page 8-4	Section 8.1.5.5 and 8.1.5.6	Drawing info added	For new sealed split lid CV and clarification
Page 8-6	Section 8.2 – 4th para	“as specified” added	Clarity
Page 8-7	Section 8.2.2.3 – all paras	Loading requirements added for sealed split lid CV	For new CT-6
Page 8-8	Section 8.2.3.1 – 2nd paras	Drawing info added	For new sealed split lid CV and clarification
Page 8-8	Section 8.2.3.2 – para 3)	“as specified” added	Clarity
Page 8-9	Section 8.2.3.2 – para 8)	“as specified” added	Clarity
Page 8-9	Section 8.2.3.3 – title	Editorial	Clarification
Page 8-9	Section 8.2.3.3 – para 6)	Drawing info added	For new sealed split lid CV and clarification
Page 8-10	Section 8.2.3.3 – para 7)	Reference added to the section giving the leak test requirements rather than repeating them	Consistency
Page 8-10	Section 8.2.3.3 – para 8)	“as specified” added	Clarity
Page 8-10	Section 8.2.3.4 – para 2)	“as specified” added	Clarity
Page 8-11	Section 8.2.3.5 – para 6)	“as specified” added	Clarity
Page 8-11	Section 8.2.3.6 – para 2)	“as specified” added	Clarity

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	**Location**	**Change**	**Reason for Change**
Page 8-11	Section 8.2.3.7 – title para 2)	Editorial “as specified” added	Clarity
Page 8-12	Section 8.2.5.3	“as specified” added	Clarity
Page 8-13	Table 8-1	Insert O-ring added Split lid sealed plug O-ring	Completeness For new sealed split lid CV

4 NRC Questions and Croft Responses

This section is provided to document all NRC Questions and Croft Responses.

Table 2 - Question and Response Matrix Table

Q#	Review Question	Croft Response	Changed Item
	None at this time		

Appendix A New or edited Supporting Documents provided in the SARP from Rev 13

Supporting Documents provided in the SARP at Rev 14

Table 3 - New or edited supporting documents provided in the SARP

Related SARP Section or Doc	Document Reference		Title
Section 1 - General Information			
Documents in Section 1.3.3, Licensing Drawings			
Addition	1C-7940	A	Cover sheet for Safkeg-HS Design No. 3977A – Sealed plug
Addition	0C-7941	A	Safkeg-HS Design No. 3977A – Sealed plug
Addition	0C-7942	A	Keg Design No. 3977 – Sealed plug
Addition	0C-7943	A	Cork set for Safkeg-HS – Sealed plug
Addition	1C-7944	A	CV Design No. 3978 – Sealed plug
Addition	1C-7945	A	CV lid – Sealed plug
Addition	1C-7946	A	CV body – Sealed plug
Addition	1C-7947	A	Containment vessel plug – Sealed plug
Documents in Section 1.3.4 Supporting Documents			
Update	PCS 038	I	Package Contents Specification for Safkeg-HS - Package Design No 3977A
Section 5 – Shielding Evaluation			
Addition	CS 2018/01	A	SAFKEG-HS 3977A - Gas contents limit for leaktight condition – Thorium target
Documents in Section 5.5.2			
Addition	Atkins report: 5163778-HS-REP-001-001	Iss 001	HS Container Shielding Assessment with Thorium Target

Appendix B Contents Type CT-6 – Thorium Target

This appendix is provided to explain the approach taken for contents type CT-6 which is for a radioactive thorium target.

The radioactive content of the thorium target arises from proton irradiation at typically 200 uA for > 1 day to produce nominally 0.2 Ci Ac-225 at EOB [End Of Beam - removal from the proton beam]. The target is allowed to decay for at least 24hour after EOB to allow short halflife radionuclide to decay and reduce the radiation dose from the target. LANL and BNL propose to irradiate similar thorium targets with similar but different proton beam energy, current and time. The radionuclides produced by proton irradiation have been calculated using MCNP by both LANL and BNL – the LANL situation produces higher secondary nuclides [the principal being Ac-225] - the results are given in SARP Section 1.3.4.

The results of the Monte Carlo shielding calculations, for the radionuclides present in nominally >0.5% of total activity at EOB in a typical thorium target, are reported in Atkins report 5163778-HS-REP-001-001 (Section 5.5.2). The calculations determine the dose rate at the base of the package for 1 Ci of each nuclide listed in the contents (which is the location of the highest external surface dose rate).

Under NCT and HAC, it is assumed that the contents (thorium target) are contained in the CV cavity by the form of the thorium metal and sealed Inconel housing (and product container where used) and by the seal system provided by the CV and sealed split CV lid with the target being restrained to sit in the axial centre of the CV cavity.

The dose rate at the base of the package for a typical thorium target (thorium metal disc in Inconel housing) has been calculated for the radioactive content of the thorium target from proton irradiation at LANL with 24h decay after EOB. The data is presented in PCS 038 (see SARP Sections 1.3.4 and 5.5.4.3).

The calculations of the radionuclides produced by proton irradiation indicated a very large number of radionuclides but with most in small quantities and most individually < A2. Also, many radionuclides have short halflives. It is recognized that there may be variations in the radionuclide content due to variations in the exact composition of both the thorium metal disc in Inconel housing and to the irradiation parameters (proton beam energy, current and time), which would produce package external dose rates which would differ to some extent.

The shielding calculations reported in PCS 038 (based on Atkins report 5163778-HS-REP-001-001 (Section 5.5.2) show that the dose rate on the external surface of the package may be close to the non-exclusive use regulatory limit of 2 mSv/h but will be within the Exclusive Use limits for a shipment. The calculated maximum package dose rate for the activated LANL thorium target is 5.26 mSv/hr at 1 day from EOB: this reduces to 1.52 mSv/hr at 2 days from EOB.

The package maximum surface dose rate, heat output, #s of A2 and mass of radioactive material for a thorium target activated in the LANL proton accelerator are given in SARP Section 1, Table 1-4-6 [taken from PCS 038]. It can be seen that most of the radionuclides are present in <A2.

These are considered to be typical for such activation. A calculation of the activation in the BNL proton accelerator also for 0.2 Ci Ac-225 at EOB (same as for the LANL case) showed that the secondary radionuclides would be present in smaller quantities than calculated for the LANL case.

Considering the factors that affect package safety, it is noted that for the typical activated thorium target (the LANL case) the data in PCS 038 (see SARP Section 1.3.4) shows the following.

- The heat output is < 1W (the package is design for a maximum of 30W).
- Only 12 nuclides are present at > A2 quantities with the total for the target being 76 A2s.
- The halflives are short with the longest being 10 days for Ac-225.
- The maximum dose rate at the package surface is less than the regulatory limit of 10 mSv/hr for shipment under Exclusive Use – this may require decay of just a little more than 24 hr as the conservatively calculated dose rate at 24 hr from EOB is 10.7 mSv/hr.
- Radioactive gases are present in less than the allowable limits calculated for gas leakage (at ~2% of allowable leakage rate of 10-6 A2/hr).
- Total mass of radioactive nuclides is < 1g – all distributed though the thorium and Inconel metal parts of the target.

As noted above, the calculated heat output, gas leakage, and radiation dose are within the package and regulatory limits with the dose rate being closest to the regulatory limit.

As the nuclide content of the thorium target can vary, but with the calculated dose rates being within the regulatory limit, it is proposed that the criteria for allowing shipment be as follows.

- The maximum activity of Ac-225 shall be up to 7.9 GBq (0.2 Ci) with other radionuclides arising from proton irradiation of the thorium target in its Inconel housing.
- The external dose rate on the package (top, side and bottom) shall be monitored and the package may not be shipped if this exceeds 10 mSv/hr.

It is proposed that only the activity of Ac-225 (being the principal radionuclide of interest) be reported on the shipping labels and documentation and the there is no need to the shipper to establish that the limit for the radionuclides calculated to be in the thorium target are less than specified limits.

Appropriate conditions have been added in the SARP in Section 1, Table 1-3-6 for CT-6.